Dental Traumatology

Dental Traumatology 2011; **27**: 484–488; doi: 10.1111/j.1600-9657.2011.01030.x

Detection of vertical root fracture using cone beam computed tomography: report of two cases

CASE REPORT

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Accepted 24 May, 2011

Abstract – Vertical root fractures (VRFs) often occur in endodontically treated teeth and in patients older than 40 years of age. However, VRFs in teeth without endodontic treatment are relatively uncommon. VRFs are difficult to diagnose as the symptoms are non-specific or often delayed. The most common radiographic findings are thickening of the periodontal ligament, deep, localized, vertical bone loss, and localized periradicular bone loss. The explicit feature for detecting VRFs is direct visualization of a radiolucent fracture line on radiographs. However, the fracture line can be difficult to directly visualize in conventional diagnostic methods such as periapical radiographs. If unrecognized, VRFs can lead to frustration and inappropriate endodontic treatment. The two cases reported here demonstrate that the use of cone beam computed tomography (CBCT) successfully diagnoses VRFs on teeth without representative clinical and periapical radiographic findings. The clear fracture line can be discerned from the images of CBCT. Thus, CBCT imaging is useful in rapid diagnosis of VRFs and designing of further treatment.

Vertical root fractures (VRFs) are characterized by an incomplete or complete fracture line that extends through the long axis of the root toward the apex. Diagnosis is usually confirmed through the clinical signs and radiographic features, which can include the deep, narrow, and isolated periodontal pocket on the buccal aspect, the highly located sinus tract, the typical bone resorption, and the 'halo' and 'periodontal type' of bone radiolucency (1). Currently, clinical and X-ray examinations are the only useful tools that we have, but even these have shortcomings. There are often no typical clinical and radiographic features, which indicate that root fracture is present and signs and symptoms are often delayed (2). If unrecognized, VRFs can lead to frustration and inappropriate endodontic treatment. Early detection of fractured tooth is vital to prevent extensive damage to the supporting tissues. Therefore, in most cases, tooth extraction is the only reasonable treatment when the VRF is finally diagnosed (3).

As clinical and radiologic signs of vertical fractures are often non-specific and slow to develop, is direct visualization of a radiolucent fracture line on radiographs an important explicit feature for detecting vertical fractures. However, conventional diagnostic methods such as periapical radiographs only provide two-dimensional (2D) images representation of three-dimensional (3D) anatomic structures. Furthermore, the superimposition of other structures limits the sensibility of conventional radiographs for the determination of VRFs.

Other radiographic methods for detecting root fractures such as conventional computed tomography (CT) are superior to periapical radiograph (4). However, the radiation dose of CT was reported to be 20-fold higher or greater than that of panoramic radiography, depending upon the particular CT protocol (5). Moreover, Ngan et al. (6) reported that the effective absorbed radiation dose of conventional CT was 210-fold compared with the panoramic radiography. In addition, because of the increased cost and limited availability in hospitals, the use of CT in dentistry has reduced in popularity.

Recently, cone beam computed tomography (CBCT) has been specifically designed to display small parts of the jawbone with an image field size, appropriate for the most effective dentistry use (7). CBCT has been used in dentistry for the analysis of periapical lesions, endodontic surgery, implant planning, the temporomandibular joint, and resorptions (8). High-quality CBCT technology improves diagnosis and treatment planning of endodontic cases for dentists and leads to improve

patient care and treatment outcomes. CBCT provides 3D images and eliminates superimposition of anatomic structures, which allows the clinician to clearly analyze the fracture (9, 10). The low radiation dose to the patient should also be mentioned. CBCT could be generated at relatively low radiation doses and a high resolution compared with conventional CT (11).

The present cases include a non-endodontically and an endodontically treated tooth, both of which have no typical clinical and radiographic features of VRFs. Fracture lines were diagnosed with the help of CBCT. Finally, VRFs were confirmed by directly observing the extracted root.

Case presentations

Case 1

A 56-year-old Chinese female patient presented a dull pain involving tooth 36 when chewing food. She reported some habits such as chewing hard foods and bruxism. Clinical examination revealed the presence of occlusal wear on tooth 36. No periodontal abscess and sinus tract were observed. This tooth was sensitive to percussion and displayed grade 1 mobility. Cold and electrical pulp testing elicited a negative response. Periodontal examination disclosed a 4-mm pocket on the distofacial surface of the tooth. Periapical radiograph showed that tooth 36 has a distal-cervical deep caries lesion, which may have caused pulp necrosis, ending up in sensitivity to percussion. A radiolucency area at the septum level was also detected, compatible with pulp necrosis. In addition, periapical radiograph also revealed a thickening periodontal ligament around the mesial and distal roots (Fig. 1a). However, the fracture line on the root was not visualized on periapical radiograph. For a further examination, with the patient's consent, CBCT images of this tooth and the surrounding jaw area were taken using 3DX Accuitomo (Morita Co., Tokyo, Japan) at 80 kV and 5.0 mA and exposure time was 17.5 s. A protective lead apron was used to decrease radiation dose. Image data were collected during a single 360° rotation round the patient. Volume reconstruction was performed on dedicated software (I-dixel; J. Morita, Kyoto, Japan) with an approximate reconstruction time of 2 min. CBCT images were analyzed using software 3DX (One volume Viewer; J. Morita) for MPR evaluation, which displays the volume in high resolution in three planes (axial, sagittal, and coronal) with very little interference from artifacts. In CBCT images, axial views directly showed a root fracture in the mesial root (Fig. 1b). Slices of the tooth were obtained at different levels to determine the origin of the root fracture. The CBCT scan slices revealed the origin of the fracture line in the middle third section and end in the apical part of the root (Fig. 1b). The fracture line was not detected in the coronal third of the root. The suspected VRF was confirmed, and a diagnosis of the VRF was made. To avoid the unnecessary endodontic treatment and extensive damage to the supporting tissues, the tooth was immediately extracted under local anesthesia. Then, the vertical fracture in the apical part of the mesial root was visualized (Fig. 1c). The image of the extracted root revealed that the fracture line started in the middle third and ended in the apical part, consistent with the CBCT images.

Case 2

A 50-year-old Chinese female patient presented with moderate pain when biting or chewing from tooth 25 after root canal treatment by several local dentists.

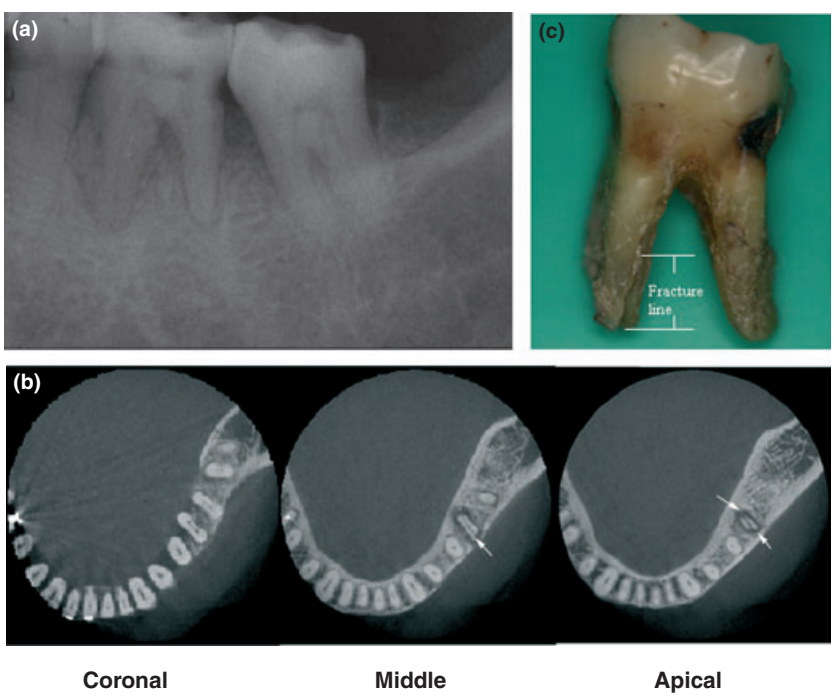

Fig. 1. Radiographic view of the tooth 36. (a) Periapical radiograph shows a thickening periodontal ligament around the mesial and distal roots, a distal-cervical deep caries lesion, and a radiolucency area at the septum. (b) Axial cone beam computed tomography slices at coronal, middle, and apical reveal a fracture line (arrow) on root. (c) A VRF (arrow) is visualized on the extracted tooth.

Dental history revealed that she had undergone root canal treatment 5 months earlier. The patient reported that teeth 16 and 46 were extracted 15 years prior. She confirmed the presence of unilateral chewing. Clinical examination showed that tooth 25 was painful on palpation and percussion, but not mobile. No periodontal abscess and sinus tract were observed. Periodontal examination showed no abnormal gingival pockets around tooth 25. Periapical radiograph revealed that the canal appeared to be completely obturated, and there was a periradicular radiolucency located at the mesiofacial surface of the root (Fig. 2a). Considering the patient's medical history and radiographic findings, a vertical fracture on the tooth was suspected. For a further examination, with the patient's consent, CBCT was used to better explore the area around tooth 25. Also, a protective lead apron was used to decrease radiation dose. Axial and coronal CBCT views showed a vertical fracture line on the tooth (Fig. 2b). Considering the findings of CBCT images, the diagnosis of root fracture was made. To prevent subsequent destruction of the adjacent bone, the tooth was immediately extracted under local anesthesia. A vertical fracture on the root was directly visualized by detailed inspection of the extracted tooth (Fig. 2c).

Discussion

In both cases reported here, the root fractures were detectable three-dimensionally and could be visualized precisely with CBCT. The qualitative detail of the fracture line was evaluated with CBCT at various sections and then compared to that seen in photographs of the extracted teeth. The root fractures revealed in CBCT images were consistent with the photographs of the extracted teeth.

VRFs often occur in endodontically treated teeth and in patients older than 40 years of age (1). However, VRFs in teeth without endodontic treatment are relatively uncommon. A few Chinese have been reported by Wei (12) and Yang (13), who reported three cases and 12 cases, respectively, of VRFs in non-endodontically treated teeth. Chan et al. (14) reported 64 cases of VRFs in non-endodontically treated teeth in Chinese populations. Cases of vertical root fracture necessitate extraction of the tooth, because infection develops from the marginal periodontium, with subsequent destruction of the adjacent bone. A quick decision to extract the tooth or root is necessary to stop rapid bone loss once the fracture communicates with the oral environment. Hence, accurate diagnostic information leads to better treatment-planning decisions and potentially more predictable outcomes. Although a number of diagnostic reviews have been published (1, 2), diagnosis is sometimes difficult as signs and symptoms and radiographic features can be misleading and typical of other periapical diseases (15). Clinical signs of the fracture develop slowly and are usually not apparent until 1 or 2 years after injury. Radiologic signs of VRFs are highly non-specific and may be seen in other endodontic diseases that necessitate completely different

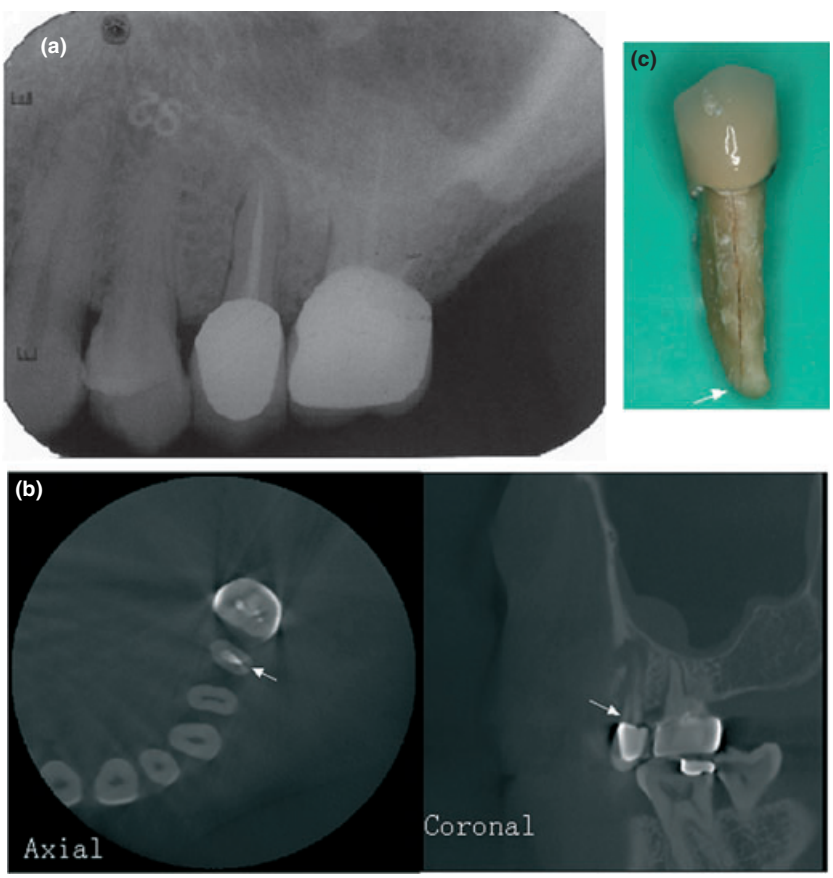

Fig. 2. Radiographic view of the tooth 25. (a) Periapical radiograph shows lateral radiolucent areas locate at mesial aspect of the tooth. (b) Axial and coronal cone beam computed tomography views show a VRF (arrow) on the tooth. (c) A VRF (arrow) is visualized on the extracted tooth.

therapeutic management. Thus, it would be advantageous to find a more efficient and reliable means of establishing the diagnosis preoperatively so that prosthetic rehabilitation may be initiated and the costs and effort of an ineffective apical root resection may be avoided. In the present two cases, clinical and periapical radiologic signs of the teeth were non-specific. Furthermore, the fracture line could not be visualized directly on periapical radiographs. However, the fracture line was visualized precisely with CBCT. The present case reports confirm the diagnosis of VRFs with the help of CBCT. Early detection of VRFs in teeth avoids unnecessary bone loss, which can result in difficulty in reconstructing a bone area where implants is the treatment of choice in the fracture. Therefore, CBCT can be recommended when a fracture is suspected clinically and when conventional radiography is negative.

A fracture line is observed on periapical radiograph in only 35.7% of cases (16). Periapical radiographs suffer from superimposition artifacts inherent to the scan method, frequently limiting the sensibility of radiographs for the determination of VRFs. The CBCT provides cross-sectional imaging and eliminates superimposition of anatomic structures, which allows the clinician to clearly analyze the fracture. Another issue to be considered is the image artifacts caused by metallic restorations, root canal filling, and implants. These can cause bright or dark streak in CBCT images, which might impair diagnoses (17–19). However, Loubele et al. (20) found that CBCT images are much less disturbed by these artifacts compared with multislice CT. In the second case reported here, root canal filling was performed on tooth 25, and the tooth was restored with crowns. The CBCT images showed that the fracture line began at the junction of the prosthetic crown, extending to the apical apex. Metallic restoration and root canal filling did not affect the fracture line in this case. So in this instance at least, the artifacts did not interfere with making a correct diagnosis.

When using radiation, the principle of as low as reasonably achievable (ALARA) should always be in consideration (21). Periapical radiographs have the advantage of a low-effective radiation dose, but VRFs are not readily visualized. On the other hand, CT scans carry a higher radiation risk without the necessary rewards. CBCT has low radiation levels and a high resolution, therefore, it is suitable for the detection of VRFs. In addition to this advantage, there are many other advantages of CBCT. When compared with conventional periapical radiography, CBCT eliminates superimposition of surrounding structures, providing additional clinically relevant information (22). As compared with conventional CT, CBCT has increased accuracy, higher resolution, reduced scan time, and reduced cost for the patient (23, 24). Because of these advantages, CBCT becomes a viable technique for the detection of root fractures.

In conclusion, based on the result of these two cases, when there are no typical clinical and radiographic features which indicate that root fracture is present, CBCT may be an alternative option for the detection of root fractures.

Acknowledgements

This work was supported by the Key Clinical Program of the Ministry of Health of China. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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